

A New Genus of Australian Soft Scale Insect (Hemiptera: Coccidae) with Species on *Capparis* (Capparaceae) and *Doryphora* (Monimiaceae) from New South Wales

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A new genus, *Austrolecanium* (Hemiptera: Coccidae: Coccinae), is erected for two species of soft scale from New South Wales. *A. sassafra*, sp. nov., is bright green in life and occurs on the leaves of *Doryphora sassafra* Endl. (Monimiaceae) in wet gullies in the Blue Mountains and near coastal New South Wales. *A. cappari* (Froggatt), comb. nov., has been collected from the leaves of *Capparis mitchellii* Lindley (Capparaceae) in north-western New South Wales. Both species appear to be ovoviviparous and four female instars are known for *A. sassafra*. The adult female and first-instar nymph of *A. cappari* and *A. sassafra* and the second-instar male of *A. sassafra* are described and illustrated. A key to separate the female instars and the second-instar male of *A. sassafra* is provided. An apparently predatory cecidomyiid (Diptera) associated with the brood of *A. sassafra* is reported.

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INTRODUCTION

The Australian soft scale insects (family Coccidae), especially endemic species, are poorly known. Other than taxonomic studies of *Ceroplastes* (Qin and Gullan 1994), *Cryptes baccatus* (Farrell 1990) and the Pulvinariini (Qin and Gullan 1992), the only well-known species are a few cosmopolitan pests, such as *Coccus hesperidum* Linnaeus, *Parasaissetia nigra* (Neitner) and *Saissetia oleae* (Olivier) (Williams and Watson 1990), and the type species of three Australian genera, *Alecanopsis* Cockerell, *Austrolichtensia* Cockerell and *Ceronema* Maskell (redescribed by Hodgson 1994). Most species cannot be identified, often not even to genus, with the available literature. Froggatt's (1921) revision of Australian scale insects is the last major taxonomic work to treat the Australian Coccidae as a whole and many of the names and generic concepts used by Froggatt are no longer valid.

Recently, some bright green scale insects of an undescribed species of coccid were collected on the leaves of sassafras, *Doryphora sassafra* Endl. (Monimiaceae). The infested host tree was growing on the edge of a creek in an undisturbed, coastal forest of New South Wales. There are only two species of *Doryphora* Endl. (Boland et al. 1984) and both are endemic to Australia. *D. sassafra* occurs in wet forests of the Great

Dividing Range and coastal areas of New South Wales and Queensland (Harden 1990a) and *D. aromatica* (Bailey) L.S. Smith is confined to rainforests in north Queensland (Lassak and McCarthy 1983). The insect fauna of *Doryphora* has not been recorded, although levels of insect herbivory of the leaves of *D. sassafras* have been studied in New South Wales rainforests (Lowman 1985).

The features of the adult female of this new species place it in the tribe Paralecaniini of the subfamily Coccinae (as defined by Hodgson 1994), in which it keys out near *Platylecanium* Cockerell and Robinson, *Melanesicoccus* Williams and Watson and *Neosaissetia* Tao and Wong, although it does not closely match any of these genera. *Melanesicoccus* is known from three species (Ben-Dov 1993): the type species from Papua New Guinea and two species from the Solomon Islands (Williams and Watson 1990; Hodgson 1994). *Neosaissetia* has four described species (Ben-Dov 1993). The type species, from Taiwan, was redescribed by Hodgson (1994) and the other three species are from Papua New Guinea (Williams and Watson 1990), the Philippines (Morrison 1920) and Malaysia, Singapore and Thailand (Takahashi 1942). *Platylecanium* has 11 described species (Ben-Dov 1993), also from the Australian and Oriental regions. The only Australian species currently placed in this genus is *P. cappari* (Froggatt), which is known only from the original collection on leaves of wild orange, *Capparis mitchellii* Lindley (Capparaceae), in north-western New South Wales (Froggatt 1915).

Our detailed study of Froggatt's original material of *P. cappari* has revealed that it is congeneric with the new species from sassafras. The host plants of these two Australian coccid species are not closely related and occur in quite different vegetation types (Harden 1990a,b), although both have leaves that contain alkaloids (Gharbo et al. 1965; Lassak and McCarthy 1983; Collins et al. 1990). The foliage of *C. mitchellii* is relished by stock but there are unsubstantiated reports of the plant causing poisoning (Cunningham et al. 1981). The alkaloids of *Capparis* L. do not appear to have been identified. Both the crushed leaves and the bark of *D. sassafras* are highly aromatic and have a similar alkaloid composition, with the leaves also containing an essential oil rich in toxic safrole (Gharbo et al. 1965; Chen et al. 1974; Lassak and McCarthy 1983). The use of unrelated host plants by these two coccid species may be associated with their ability to tolerate, or perhaps even respond to, the alkaloids or other compounds. Phloem-feeding insects are not protected from the plant secondary compounds of their host plants, as evidenced by the presence of plant-derived compounds, such as alkaloids, in their honeydew (Dreyer et al. 1985; Molyneux et al. 1990).

This paper erects a new genus, *Austrolecanium*, for the two Australian species discussed above. The coccid from *Doryphora* is described as a new species and the coccid from *Capparis* is redescribed and formally transferred to *Austrolecanium*. The new genus and its two species are described and illustrated based on both the adult females and the first-instar nymphs (crawlers). In addition, the second- and third-instar females are described and the second-instar male is described and illustrated for the species from sassafras and the pupa of an apparently predatory cecidomyiid also is illustrated. Hodgson's (1994) key to coccid genera is modified to include this new genus and diagnostic features that readily distinguish the two species of *Austrolecanium* are listed.

MATERIALS AND METHODS

The descriptions largely follow the format and terminology of Hodgson (1994). To prepare adult females and nymphs as microscope slide-mounts, body contents were cleared in cold 10% w/v potassium hydroxide (KOH) solution overnight, the cuticle was stained in acid fuchsin in acid alcohol, dehydrated in three changes of absolute ethanol and one of absolute propan-2-ol and then placed in three changes of xylene prior to mounting in Canada balsam. Scanning electron microscopy (SEM) was used to examine

the cuticular structures of the first-instar nymphs. Scale insects were prepared for SEM after preservation and storage in lactic-alcohol (Upton 1991) or 80% ethanol. Each specimen was dehydrated in a graded ethanol series, dewaxed in xylene, rehydrated through a graded ethanol series into distilled water, post-fixed in 1% aqueous osmium tetroxide, washed in distilled water and sonicated briefly to remove any black precipitate, freeze-dried, glued onto a metal stub with nail varnish and coated with gold palladium under vacuum. Specimens were then examined and photographed using a Cambridge S360 SEM.

Each listed scale insect is mounted on a separate microscope slide, unless otherwise specified. All measurements were made on slide-mounted specimens.

The following abbreviations are used for depositories:

ANIC — Australian National Insect Collection, CSIRO, Canberra

ASCT — The Agricultural Scientific Collections Trust, NSW Agriculture, Orange [formerly the Biological and Chemical Research Institute (BCRI), Rydalmere]

BMNH — The Natural History Museum, London.

FCNI — State Forests of NSW Insect Collection, Beecroft, Sydney

GENUS *AUSTROLECANIUM*, GEN. NOV.

Type species: *Austrolecanium sassafras*, sp. nov., by present designation.

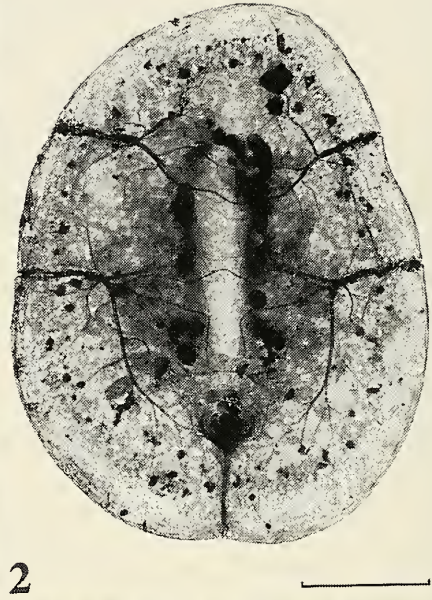
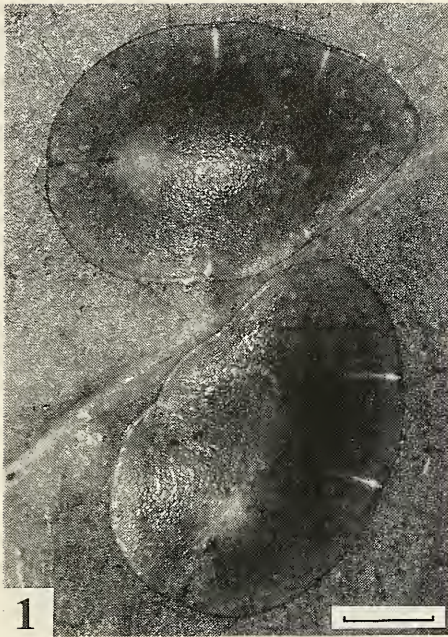
Description of adult female

Body oval, 3–10 mm long, 2–7 mm wide, generally slightly asymmetrical with one side of body slightly shorter than other (Figs 1, 4); margins of anal cleft closely adpressed; rather flat.

Dorsum membranous or only very slightly sclerotised. Eyespot present, displaced some distance onto dorsum. Dorsal setae present: flagellate or spinose. Three types of dorsal pore: (i) largest, a closed pore with a granulate surface (apparently preopercular pores), most abundant lateral to anal plates, (ii) a smaller closed pore with a granular surface, frequent elsewhere on dorsum; and (iii) a minute dorsal microductule with a long inner ductule, slightly swollen proximally; also fairly frequent throughout. Dorsal tubular ducts and dorsal tubercles absent. Anal sclerotisation absent; anal plates together approximately quadrate, each with 4 small setae near apex; no pores or ridges dorsally on plates; setae on inner margins of ano-genital fold and lateral margins variable. Anal tube usually subequal to anal plates in length; anal ring with 3 or 4 pairs of setae.

Margin with spinose marginal setae. Stigmatic clefts distinct, each with a well-defined stigmatic sclerotisation; each cleft with stigmatic spines at inner end. Anal cleft quite deep, sides closely adpressed but not fused.

Venter membranous. Ventral setae: with a single pair of long pregenital setae; other pregenital setae short and frequent in bands medially across abdominal segments; other setae most frequent mediolaterally on anal lobe, becoming less so anteriorly; submarginal setae small or minute; with 1–2 pairs of interantennal setae. Pregenital disc-pores often rather malformed, mostly with 7–9 loculi; most abundant on pregenital segment (VII) but sometimes with a few on abdominal segments III to VI. Spiracular disc-pores mainly with 5 loculi; in fairly narrow bands between spiracles and margin and extending for a short distance medial to spiracle. Preantennal pores absent. Ventral microducts minute, each with outer ductule 2–3 μm long and inner ductule inconspicuous; sparsely scattered throughout venter but concentrated in a U-shaped band surrounding labium. Ventral tubular ducts absent. Spiracles well developed, each with a conspicuous, narrow muscle-plate to peritreme. Legs much reduced, with perhaps 3 segments plus a claw; trochanter



Figures 1–2. Live adult females of *Austrolecanium sassafra* sp. nov.: 1, two females feeding near the midrib of a leaf of *Doryphora sassafra* (the paired white streaks on the coccids are due to wax in the stigmatic furrows underneath); 2, a female photographed with transmitted light to reveal the internal structures, especially the tree-like tracheal system. Figure 3. Empty test produced by a second-instar male of *A. sassafra*, showing lines and patches of white wax secreted by the dorsal tubular ducts; the sutures of the test are along the lines. Figure 4. Two dry adult females of *Austrolecanium cappari* (Froggatt) on a dry leaf of *Capparis*; four females have fallen off the leaf, leaving behind a few crawlers and piles of cast-off embryonic membranes (arrowed), which appear as white patches. Scale line on each figure = 2 mm.

fused with femur, tibia and tarsus also fused but occasionally showing slight signs of pseudoarticulation; tarsal digitules both finely knobbed and usually slightly longer than claw digitules; claw digitules longer than claw, 1 broader than other, both finely knobbed; claw small, without a denticle. Antennae reduced, each with about 6 segments, but segmentation often obscure; flagellate setae only present on basal 2 segments. Mouthparts displaced somewhat nearer to shorter side of body, otherwise apparently normal. Labium 2-segmented.

Diagnostic features of adult female

Adult females of this genus can be identified by the following combination of characters: (i) asymmetry of mouthparts; (ii) stigmatic clefts distinct, with a stigmatic sclerotisation and stigmatic spines; (iii) pregenital disc-pores generally with 7–9 loculi; (iv) absence of both dorsal and ventral tubular ducts; (v) spinose marginal setae; (vi) reduced, indistinctly-segmented antennae; and (vii) reduced legs. It appears to fall within the Paralecaniini as defined by Hodgson (1994), in which it keys out with *Neosaissetia* Tao and Wong, but can be easily separated using the following modification to Hodgson's key to adult female Coccidae:

GROUP D: subfamily COCCINAE, tribe PARALECANIINI (Hodgson 1994, pp. 78–79)

(NB. Hodgson's key is based only on the type species of each coccid genus)

8. Claws with a denticle on widest part; with 9–14 stigmatic spines present in a triangle situated at base of each stigmatic cleft; stigmatic cleft without stigmatic sclerotisation; dorsal tubercles absent *Melanesicoccus* Williams and Watson
- Claws each without a denticle on widest part; with 2–3 (occasionally more) stigmatic spines along inner margins of each stigmatic cleft, not arranged in a triangle; stigmatic clefts each with distinct stigmatic sclerotisation; dorsal tubercles present or absent 8a
- 8a Mouthparts placed asymmetrically; dorsal tubercles absent; legs distinctly reduced; claw and tarsal digitules with small apical knobs; pairs of long pregenital setae only present on pregenital segment *Austrolecanium*, gen. nov.
- Mouthparts symmetrically placed; dorsal tubercles present in a sparse submarginal ring; legs well developed; claw digitules with broad apical knobs; pairs of long pregenital setae present on posterior three pregenital segments *Neosaissetia* Tao and Wong

Description of first-instar nymph

Body of unfed crawler 430–590 μm long, 230–330 μm wide, rather oval; body becomes wider relative to length after nymph has commenced feeding (see inset AA in Fig. 7); with anal plates only slightly withdrawn into a short, wide anal cleft in youngest specimens but at end of a short anal cleft with adpressed sides in mature specimens (see inset AA in Fig. 7).

Dorsum membranous, derm corrugated on young specimens but apparently smooth on mature specimens; with a narrow, distinct, sclerotised border to stigmatic clefts; segmentation visible on thorax and abdomen. Eyespot present on margin. Dorsal setae minute (length approximately equal to diameter of basal socket), in 3–4 pairs medially on head and thorax. Dorsal pores of 3 types: (i) a small simple pore in a submarginal line; (ii) a microductule, which is either minute or much enlarged into a figure-of-eight pore, fairly frequent over most of dorsum; and (iii) a pair of minute trilocular pores near anterior margin of head. Dorsal tubular ducts, preopercular pores and dorsal tubercles absent. Anal plates together quadrate, but rather elongate, each with a very long apical

seta, 2 small setae on inner margin and another near apex on posterior margin. Anogenital fold with a single pair of small setae anteriorly and another pair on lateral margins; supporting bars distinct. Anal ring with 3 pairs of setae; anal tube rather short, less than half length of plates.

Margin with a row of finely spinose marginal setae, distribution typical of first-instar coccids, with 6 pairs anterior to anterior stigmatic cleft, 2 (rarely 3) setae between anterior and posterior clefts and 8 pairs posteriorly on abdomen; setae on head longest. Stigmatic clefts shallow, each with a distinct stigmatic sclerotisation and 2 stigmatic spines that point posteriorly, 1 spine longer than other; usually with a marginal seta closely associated posteriorly.

Venter membranous; segmentation visible on thorax and abdomen. Ventral setae flagellate, distributed as follows: 1 pair of long pregenital setae (occasionally 1–2 more pairs present); 1 pair of long interantennal setae; all other setae much shorter: 1 pair per segment in a mediolateral line on abdomen, 1 pair medially associated with each meso- and metacoxa, and in a sparse submarginal line on each side of body with 7 setae on abdomen, 1 between stigmatic clefts, 0–1 laterally on prothorax, plus 1 anteriorly on head. Pregenital disc-pores absent. Spiracular disc-pores in a single line of 2–5 pores per stigmatic furrow with none extending medially past peritreme; each pore with 3–7 loculi. With a single pair of ventral microducts, midway between pro- and meso-coxae; very occasionally one present elsewhere. Spiracles small. Legs well developed, each trochanter with a single long seta; tibia with a longish seta on ventral margin and 2 other short setae; tarsal digitules dissimilar, 1 much longer and broader than other, both with knobbed apex except on prothoracic tarsus where 1 digitule flagellate; claw digitules dissimilar, one broader than other, both shorter than tarsal digitules, each with a small knobbed apex; claw 15–19 μm long with a distinct denticle. Antennae well developed, with 6 segments, apical segment rather long; penultimate 2 segments each with a flagellate seta in addition to a fleshy seta; third segment with 2 long and 1 short flagellate setae. Mouthparts centrally placed (even on older nymphs) and typical of Coccidae.

Diagnostic features of first-instar nymph

The most striking features of the crawler are as follows: (i) the stigmatic sclerotisation; (ii) presence of two stigmatic spines, both pointing posteriorly; (iii) presence of dorsal setae; (iv) dissimilar tarsal digitules; (v) dissimilar claw digitules; (vi) presence of a denticle on claw; (vii) presence of single seta on each trochanter; and (viii) presence of a flagellate seta on penultimate two segments of antennae.

Included species

The genus *Austrolecanium* has been erected for two species (*A. sassafra*, sp. nov., and *A. cappari* (Froggatt), comb. nov.), restricted to eastern Australia. For separation of these species, refer to the diagnoses that follow the descriptions of the adult female and first-instar nymph of each species.

AUSTROLECANIUM SASSAFRAS, SP. NOV. (FIGS 1–3, 5–7)

Material examined

Types

Holotype, adult female, NEW SOUTH WALES: Yadboro State Forest, off Western Distributor Rd, on Carters Creek, 35°31'00"S, 150°03'20"E, ex leaf of *Doryphora sassafra*. 5.vii.1995, P.J. Gullan (ANIC), hereby designated.

Paratypes. NEW SOUTH WALES: 13 adult females, same data as holotype (9 ANIC; 1 ASCT, 1 BMNH; 2 FCNI); 2 adult females, 2 third-instar females containing pharate adults, 1 pharate second-instar female (on slide with first-instar nymphs), 5 second-instar males, 87 first-instar nymphs (10 slides, 5 of which also have cecidomyiid pupae), same data as holotype except 12.i.1996 (ANIC except 1 slide with 8 first-instar nymphs and 1 cecidomyiid pupa in BMNH); 5 mature first-instar nymphs, same data as holotype except 16.ix.1996 (ANIC); second-instar males (1 slide), same data as holotype except 28.ix.1996 (ANIC); 2 adult females, same data as holotype except 3.iv.1996, B.A. Melbourne (ANIC); 1 adult female, Blue Mountains, Nellys Glen, ex sassafras, WWF 699 (ANIC); 2 adult females, ex *Doryphora* sp., Wollongbar, 7.viii.1989, V.B. Robinson (ASCT).

Other material

In addition to the slide-mounted type specimens listed above, there are numerous unmounted specimens of adult females and first-instar nymphs both dry and preserved in lactic-alcohol. These are excluded from the type series.

Key to instars (excluding prepupal, pupal and adult males)

1. Stigmatic clefts each with 6–12 stigmatic spines of differing lengthsadult female
 - Stigmatic clefts each with 4–5 stigmatic spines, 2 longer and stouter than others
.....third-instar female
 - Stigmatic clefts each with 3 stigmatic spines, 2 much longer than third
.....(second-instar nymph) 2
 - Stigmatic clefts each with 2 stigmatic spines, 1 longer than other ...first-instar nymph
2. Dorsum with tubular ducts arranged in distinct linessecond-instar male
 - Dorsum without tubular ductssecond-instar female

Description of adult female

(Figs 1, 2, 5) (measurements based on 10 specimens)

Live specimens bright green with shiny dorsum, especially in mature females; young adults partially transparent so that internal organs are visible in transmitted light (Fig. 2).

Body oval and usually asymmetrical, 5.4–9.5 mm long, 3.7–7.0 mm wide.

Dorsum membranous except for a distinct, clearly marked area of sclerotisation around inner margin of each stigmatic cleft on all specimens, and areas of slight sclerotisation around body margin and anal plates on old specimens. Eyespot far from body margin, just anterior to level of antennal bases. Dorsal setae flagellate, 15–30 μm long, frequent throughout but most abundant and slightly longer near anal plates. Dorsal pores of 2 kinds: (i) minute microductules, 1 μm in diameter, with inner ductule tubular and 5–7 μm long at its proximal end, filamentous distally; frequent and fairly evenly distributed throughout; and (ii) simple, closed, pores, 3–5 μm in diameter, scattered over dorsum, but largest in a broad area around anal plates; latter, larger pores probably preopercular pores. Anal plates each triangular with anterior and posterior margins subequal, each plate 200–240 μm long, 95–120 μm wide; with 2 setae apically on each plate plus a small seta and a slightly longer seta posteriorly on posterior margin. Anogenital fold with 2 pairs of setae along anterior margin, approximately of equal length, 35–80 μm long; also with a distinct supporting bar on each margin, with 6–10

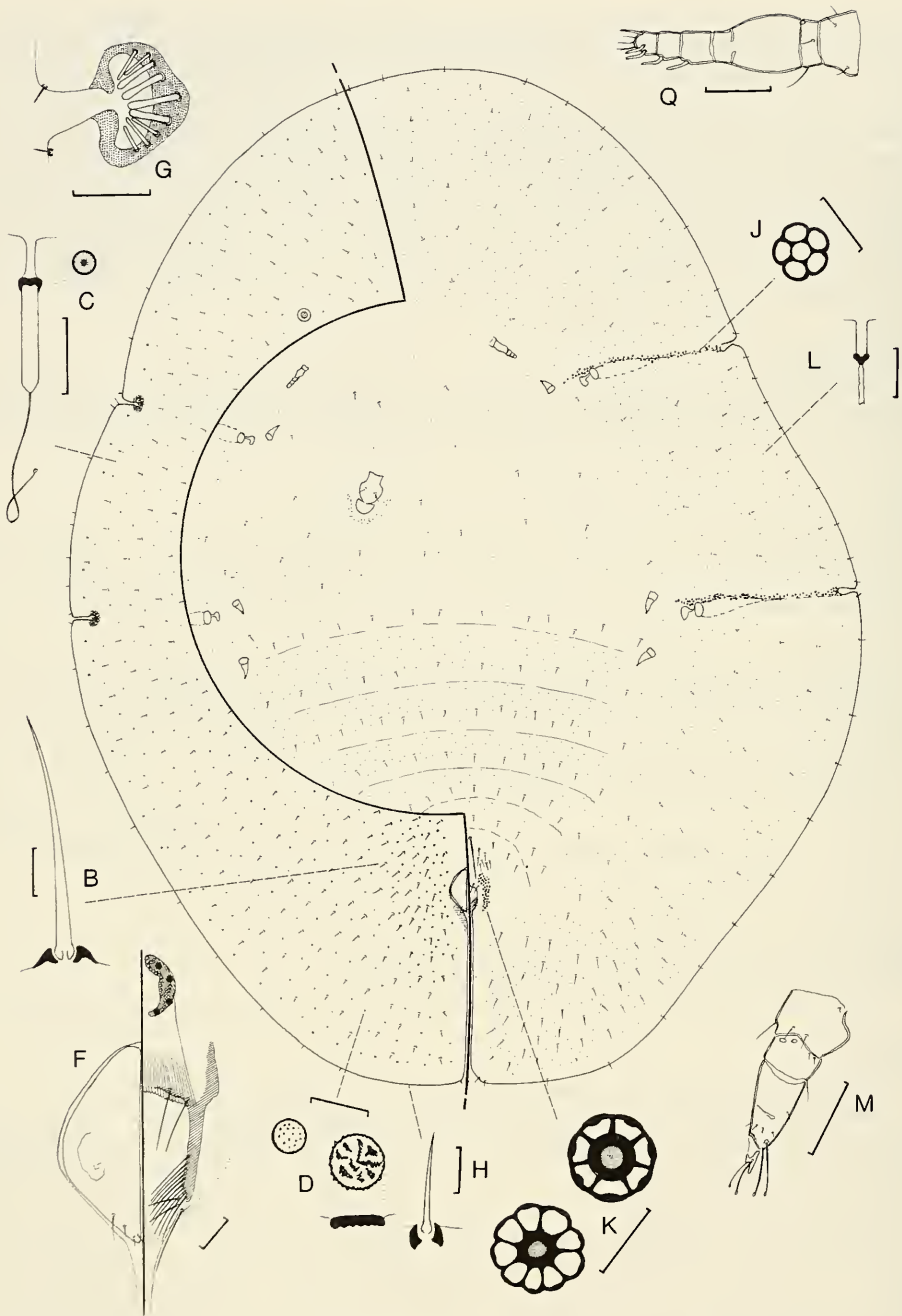


Figure 5. Adult female of *Austrolecanium sassafra* sp. nov. Unless otherwise stated, the letters on this and the following figures refer to the following structures: A, dorsal trilocular pore; B, dorsal seta; C, dorsal microduct; D, dorsal simple pore; E, dorsal tubular duct; F, anal plates and anogenital fold; G, stigmatic area; H, marginal spinose seta; J, spiracular disc-pore; K, pregenital disc-pore; L, ventral microduct; M, complete metathoracic leg or part thereof; N, tarsus and claw of prothoracic leg; Q, complete antenna. In addition, unless otherwise stated, the scale lines against each vignette are as follows: anal plates (F), stigmatic cleft (G), leg (M) and antenna (Q) = 50 μ m; all other structures = 5 μ m.

setae (40–75 μm long) in a line on either side, plus 3 pairs of setae more posteriorly. Anal tube slightly shorter than length of anal plates; anal ring 70–83 μm in diameter, with 4 pairs of setae, each 225–275 μm long.

Margin with setae finely spinose, \pm straight, shorter than dorsal setae, 12–20 μm long, in a single marginal row but absent from stigmatic and anal clefts; with 4–11 setae on each side between lateral stigmatic clefts; anal lobe setae not differentiated. Each stigmatic cleft rather 'mushroom-shaped', i.e. with narrow cleft broadening into a wide space; each with a well-defined area of sclerotisation along inner margins of cleft; each cleft with 6–12 stigmatic setae; each seta 13–50 μm long, parallel-sided, with a rounded, often slightly clavate apex.

Venter with segmentation only visible medially on thorax and abdomen. Ventral setae flagellate, sparsely scattered but longest and most abundant mediolaterally on anal lobes; pregenital segment (VII) with a single pair of long pregenital setae, 115–140 μm long, and a group of 8–12 shortish flagellate setae just anterior to each group of pregenital disc-pores; other setae medially on abdomen, with pairs per segment: VI 7–19; V 7–10; IV 7–10; III 9–11; II 10–11; also with 1–2 pairs of interantennal setae; submarginal setae sparse. Pregenital disc-pores 4–6 μm in diameter, with mostly 7–9 loculi, sometimes slightly misshapen, in two groups of 25–40 pores on either side of ano-genital fold and occasionally with 0–2 on either side mediolaterally on previous segment. Each stigmatic furrow with a narrow band of spiracular disc-pores, each with 3–5 (mostly 5) loculi and 3–6 μm in diameter, with 45–160 pores between spiracle and stigmatic cleft; each band extending a short distance (up to 8 pores) medially past peritreme. Ventral microducts as in generic description, but also frequent in a broad submarginal band. Spiracles: anterior spiracle plus peritreme 115–150 μm long, 80–110 μm wide; posterior spiracle plus peritreme 110–160 μm long, 80–120 μm wide. Legs each 70–140 μm long with forelegs shortest; tarsal digitules 15–28 μm long, narrower than claw digitules, 1 broader than other, both with minute apical knobs; claw digitules 10–20 μm long, rather parallel-sided, each with a minute apical knob. Antennae each with about 6 indistinct segments; total length 140–170 μm ; all setae on terminal 3 segments more-or-less fleshy, 8–28 μm long. Mouthparts positioned distinctly nearer shorter margin of body. Clypeolabral shield 170–220 μm long, 160–190 μm wide. Labium 70–80 μm long, 100–120 μm wide.

Diagnosis of adult female

The adult female of *A. sassafra* differs from that of *A. cappari* (Froggatt) comb. nov. (re-described below) in (i) having many more stigmatic setae per stigmatic cleft (6–12 cf. 1–4 in *A. cappari*); (ii) marginal setae shorter than dorsal setae; (iii) dorsal setae flagellate and rather concentrated around anal plates; (iv) ano-genital fold with a line of 6–10 setae along the lateral margins of each supporting bar, and (v) 4 pairs of setae in anal ring.

Third-instar female

(measurements based on 2 specimens each containing a pharate adult)

Body oval, 3.0–3.2 mm long, 2.2–2.3 mm wide.

Dorsum membranous except for sclerotised stigmatic clefts. Anal plates each elongate triangular, rounded laterally, 150 μm long, 60–72 μm wide. Anal ring *c.* 50 μm in diameter, with 3 pairs of setae, each 140–175 μm long.

Margin with spinose setae, 10–14 μm long, in a single marginal row. Each stigmatic cleft distinct with a well-defined area of sclerotisation along inner margins of cleft and with 4–5 stigmatic spines (2 longer and stouter than others), each parallel-sided with a blunt apex and a broad basal socket; 2 stouter stigmatic spines 28–40 μm long, 2–3 thinner spines 15–25 μm long.

Venter membranous. Stigmatic furrows each with band of spiracular disc-pores (bands difficult to discern because of pharate adult cuticle beneath), each pore mainly with 3–5 loculi and perhaps 20–25 disc-pores in each furrow. Spiracles well developed, with narrow muscle plate associated with each peritreme; length of each spiracle plus peritreme 70–85 μm long, width of peritreme 40–45 μm . Legs reduced, 90–100 μm long, indistinctly 3–4 segmented due to partial fusion of tibia and tarsus. Antennae reduced, with 6–7 segments but segmentation indistinct; total length 120–130 μm .

Second-instar female nymph

(measurements based on one partially pharate specimen only)

Body oval, 1.3 mm long, 0.9 mm wide.

Dorsum membranous except for sclerotised stigmatic clefts. Anal plates each elongate triangular and rounded laterally, each plate 90 μm long, 32 μm wide. Anal ring 35 μm in diameter, with 3 pairs of setae, each 105–140 μm long.

Margin with spinose setae, *c.* 10–12 μm long, in a single marginal row. Each stigmatic cleft distinct, with a well-defined area of sclerotisation along inner margins of cleft and with 3 stigmatic spines (2 long, 1 short), each parallel-sided with a blunt apex and a broad basal socket; spines 27–31 μm , 36–40 μm and 5–11 μm long, respectively.

Venter membranous. Stigmatic furrows each with band of spiracular disc-pores \pm 1 pore wide, each mainly with 5 loculi, 3–4 μm diameter, with 13–15 disc-pores in each furrow plus 1–2 disc-pores extending a short distance medially past peritreme. Spiracles well developed, with narrow muscle plate associated with each peritreme; length of each spiracle plus peritreme 50–60 μm long, width of peritreme *c.* 25 μm . Legs and antennae not preserved well enough to describe.

Second-instar male nymph

(Figs 3, 6) (measurements based on 7 specimens)

Body oval, 1.9–2.6 mm long, 1.2–1.7 mm wide, showing only slight signs of asymmetry; stigmatic clefts distinct, inner margins sclerotised; anal cleft closely adpressed.

Dorsum membranous except for a distinct, clearly marked area of sclerotisation around inner margin of each stigmatic cleft. Eyespot not discerned. Dorsal setae apparently absent. Dorsal pores of 2 kinds sparsely distributed throughout: (i) a minute microductule possessing an inner ductule with balloon-like proximal end (4–5 mm long) and long filamentous distal end (10–13 μm long); and (ii) a simple pore about 2–3 μm in diameter. Preopercular pores and dorsal tubercles absent. Dorsal tubular ducts present in a distinct reticulate pattern, with 2 medial lines of ducts extending anteriorly from anal plates to about dorsad to mouthparts and with 4 pairs of lines radiating from medial lines laterally to margin: 1 pair on abdomen, 1 pair to each stigmatic cleft and 1 pair on head; in addition there are submarginal groups of tubular ducts associated with each anterior 3 lateral lines plus a further 3 groups each side anteriorly on abdomen; each tubular duct with a stout outer ductule (15–22 μm long), a shorter (7–10 μm), stout, inner ductule and well-developed terminal gland. Anal plates triangular, with anterior margin slightly shorter than posterior margins, each plate 88–100 μm long, 38–41 μm wide; with 2 apical setae 20–35 μm long, plus a short seta posteriorly on posterior margin and another long seta posteriorly on inner margin. Anogenital fold with 2 pairs of setae along anterior margin, length 20–30 μm , plus 1 short seta on each lateral margin of anal cleft. Anal tube subequal to length of anal plates; anal ring 35–39 μm in diameter, with 3 pairs of setae, each 110–140 μm long.

Margin with straight and rather sharply spinose setae, 9–13 μm long, in a single marginal row but absent from stigmatic and anal clefts; with 3–6 setae laterally between stigmatic clefts; anal lobe setae not differentiated. Each stigmatic cleft quite deep, with 3 stigmatic spines; each spine parallel-sided with a blunt apex: 2 longer spines (21–40 μm

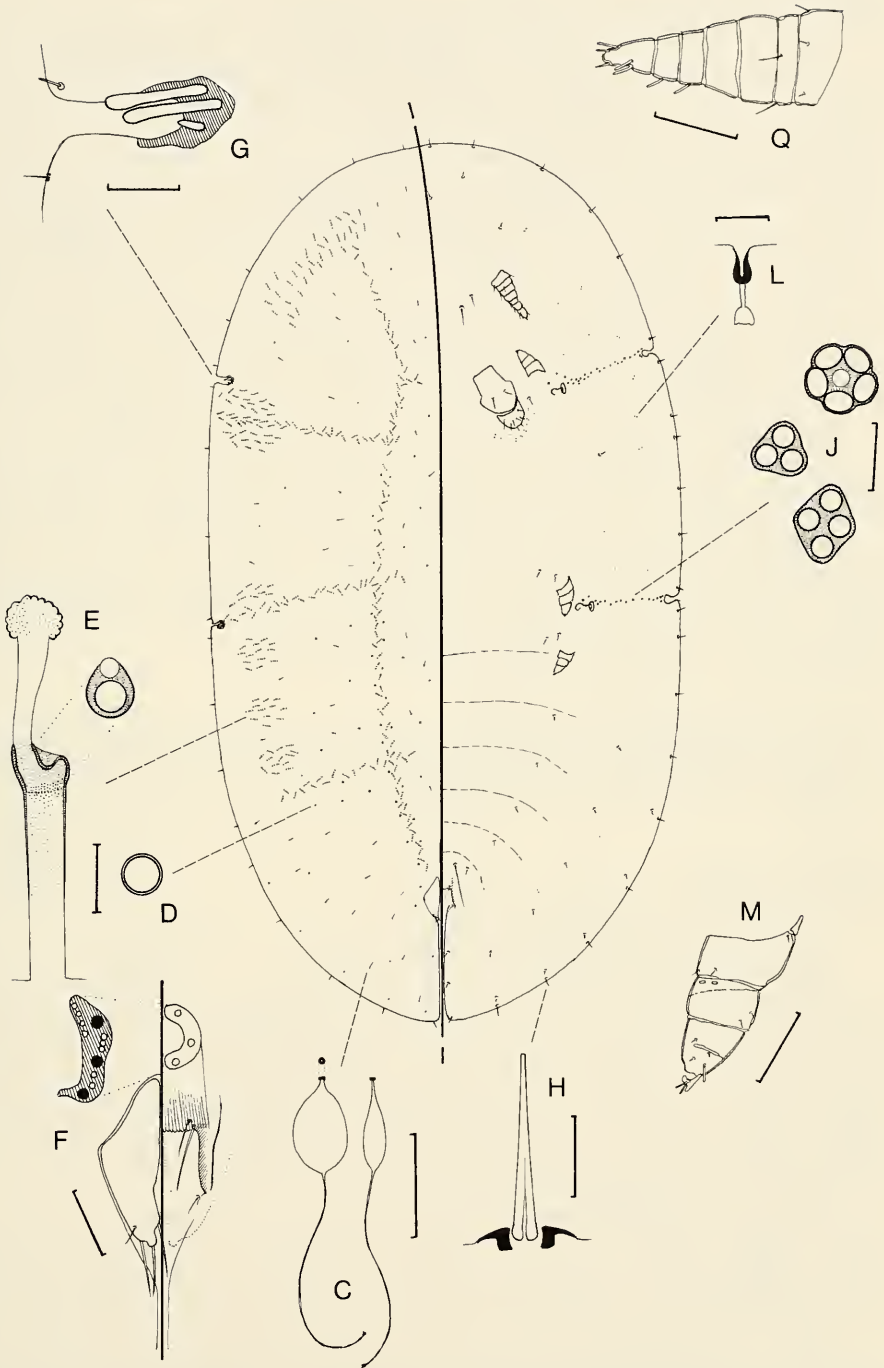


Figure 6. Second-instar male of *Austrolecanium sassafra* sp. nov. Lettering and scale lines as in Fig. 1, except that the scale line for the stigmatic cleft (G) = 25 μ m.

long) anteriorly and 1 much smaller spine (5–15 μm long) posteriorly, set in a well-defined area of sclerotisation along inner margins of cleft.

Venter with derm membranous; segmentation only visible on abdomen. Ventral setae flagellate, distributed as follows: with a single pair of pregenital setae, 55–60 μm long, and 1–2 pairs of moderately long (20–28 μm) interantennal setae; all other setae much shorter (3–5 μm long): 1 pair medially and 1 pair mediolateral on each abdominal segment; 1–2 pairs associated with each coxa; also in a sparse submarginal band, with probably 1–2 laterally between stigmatic clefts (although none visible); plus a few scattered on head and thorax. Pregenital disc-pores absent. Stigmatic furrows with band of small spiracular disc-pores \pm one pore wide, each with 3–7 (mostly 5) loculi and 4–5 μm in diameter, with 9–21 disc-pores in each furrow; also with 0–2 disc-pores extending a short distance medially past each peritreme. No preantennal pores detected. Ventral microducts 5–6 μm long, present in a sparse, broad submarginal band and also in a U-shaped band posterior to labium. Ventral tubular ducts absent. Spiracles well developed, with narrow muscle-plate associated with each peritreme; anterior spiracle plus peritreme 52–62 μm long, 25–28 μm wide; posterior spiracle plus peritreme 50–60 μm long, 25–30 μm wide. Legs much reduced, with trochanter \pm fused to femur and tibia fused to tarsus but with a pseudoarticulation, rather stout; total length 85–110 μm ; tarsal digitules much reduced, of variable length (5–16 μm) and only longer of 2 digitules with slight apical swelling; claw digitules 5–11 μm long, usually shorter than tarsal digitules, barely longer than claw and sometimes 1 digitule with slight apical swelling; each claw small, without denticle. Antennae reduced, probably 7-segmented; total length 115–135 μm ; all setae on terminal 3 segments fleshy, flagellate setae only on basal 2 segments. Mouthparts positioned distinctly nearer one foreleg. Clypeolabral shield 90–120 μm long, 100–110 μm wide. Labium 2-segmented, 50–60 μm long, 60–70 μm wide.

Diagnosis of second-instar male nymph

The second-instar male is easily distinguished from immature females by its reticulate pattern of tubular ducts on the dorsum. These ducts apparently produce a whitish wax which is visible as lines on the empty test (Fig. 3).

First-instar nymph

(Fig. 7) (measurements based on 10 specimens)

Live *specimens* with bright yellow body.

Body oval, 430–570 μm long, 230–310 μm wide.

Dorsum with dorsal setae 2–4 μm long. Dorsal pores consisting of: (i) simple pores, 2 μm in diameter, in a submarginal line extending from head to posterior abdomen; (ii) minute microductules each possessing an inner ductule with a fairly broad proximal end (4–5 μm long) and a filamentous distal end, present in a submarginal line and also medially on thorax and abdomen; and (iii) a pair of small trilocular pores near anterior margin on head. Anal plates each 60–65 μm long, 25–28 μm wide; each with apical seta 260–300 μm long. Anal ring 22–25 μm in diameter, with setae 45–80 μm long, most ventral pair shortest and thinnest.

Margin with setae, 7–20 μm long, each slightly bent posteriorly. Stigmatic clefts present but shallow, each with a distinct stigmatic sclerotisation and 2 stigmatic spines on anterior margin of cleft; 1 spine about $\frac{1}{2}$ rd– $\frac{2}{3}$ rds as long as other (lengths 8–22 μm and 29–40 μm , respectively); usually with a marginal seta within sclerotised margin posteriorly.

Venter with pregenital setae 38–55 μm long, interantennal setae 30–50 μm , all other setae 2–4 μm . Spiracular disc-pores each 2–3 μm in diameter and with 3–5 (usually 3) loculi; 3–5 (usually 4) pores in anterior furrows and 3–4 (almost always 4) pores in posterior furrows. Occasionally a ventral microduct just posterior to each scape in addition to one between fore- and midlegs. Spiracles: length of each muscle-plate plus per-

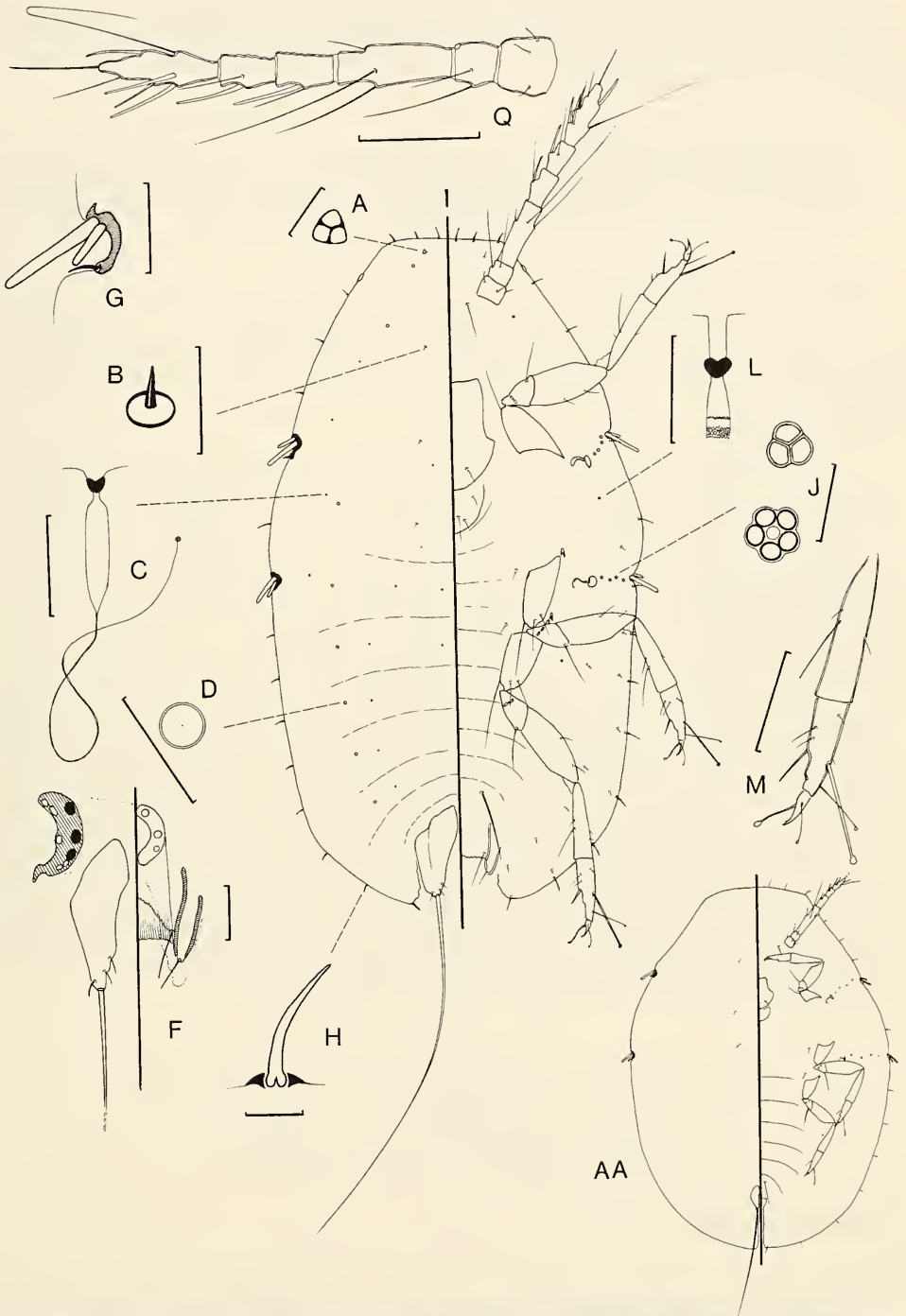


Figure 7. First-instar nymph (crawler) of *Austrolecanium sassafras* sp. nov.; inset (AA) shows the shape of the expanded body of the nymph after it has started feeding. Lettering and scale lines as in Fig. 1, except that the scale lines for the anal plates (F) and the stigmatic cleft (G) = 25 μ m.

itreme 15–22 μm ; width of peritreme 8–11 μm . Legs as in generic description. Antennae 160–190 μm long; on terminal segment: apical seta 33–44 μm long, longest flagellate seta 90–110 μm long. Clypeolabral shield 80–90 μm long, 67–80 μm wide. Labium 34–38 μm long, 45–60 μm wide.

Diagnosis of first-instar nymph

The first-instar nymph of *A. sassafras* differs from that of *A. cappari* primarily in possessing minute and scarce dorsal microductules, whereas in the latter species they are much more frequent and enlarged into ‘figure-of-eight’ pores.

Comments and biological notes

Among Froggatt’s dry collection in ANIC are three drymounts of *A. sassafras* with the manuscript name of ‘*Lecanium johnstoni*’. Apparently, this proposed name was to honour the collector. Froggatt’s accession notebook records specimens of the species under that name to be from *Doryphora sassafras* at Katoomba, collected on 20.vi.1916 by Dr S. Johnston.

Adult females of *A. sassafras* from the single infested tree at the site in Yadboro State Forest occurred mostly near veins on the underside of leaves (Fig. 3). Their honeydew, which had fallen on the foliage below, had led to the growth of black sooty mould. Females turned brown to black-brown after death. In early January 1996, there were first-instar nymphs under the bodies of adult females and newly-settled nymphs on the leaves, mostly on the upper surfaces, of the same tree. However, mature first-instar nymphs also were collected from both abaxial and adaxial leaf surfaces of the same tree in September 1996, suggesting that emergence of crawlers may occur any time from spring to summer or that two cohorts are present at the site. This species is apparently ovoviviparous. A pharate second-instar female nymph was collected in January 1996. Two dead adult females pharate in their third-instar cuticle were collected in January 1996, confirming that this species has four female instars. It was not possible to illustrate or fully describe the second- and third-instar females due to the difficulty of seeing cuticular features on the few specimens available. Several dead second-instar males were obtained from under tests (Fig. 3) on the upper surface of leaves; adult males probably are present in early summer.

Amongst the coccid progeny collected from under the female coccids were some tiny pupae of an unidentified species of Cecidomyiidae (Diptera) (Fig. 8). Pupae of only a very few Australian species of cecidomyiid have been described and none of them have been associated with coccids or *Doryphora* (P. Kolesik, pers. comm.). The cecidomyiid is probably an undescribed species (P. Kolesik, pers. comm.) and the larvae may be predatory or endoparasitic on the coccid progeny (Harris 1968).

AUSTROLECANIUM CAPPARI (FROGGATT), COMB. NOV. (FIGS 4, 9, 10)

Lecanium cappari Froggatt 1915: 604. — Froggatt 1921: 29.

Platylecanium cappari. — Ben-Dov 1993: 237.

Material examined

Types

Lectotype, adult female, NEW SOUTH WALES: Gunnedah, ex *Capparis* [as ‘*Cappras*’ on label], WWF481 (ASCT), hereby designated.

Paralectotypes. NEW SOUTH WALES: 3 adult females, 1 drymount with additional 2 adult females, same as data as lectotype (ASCT). [The dry females from Froggatt’s

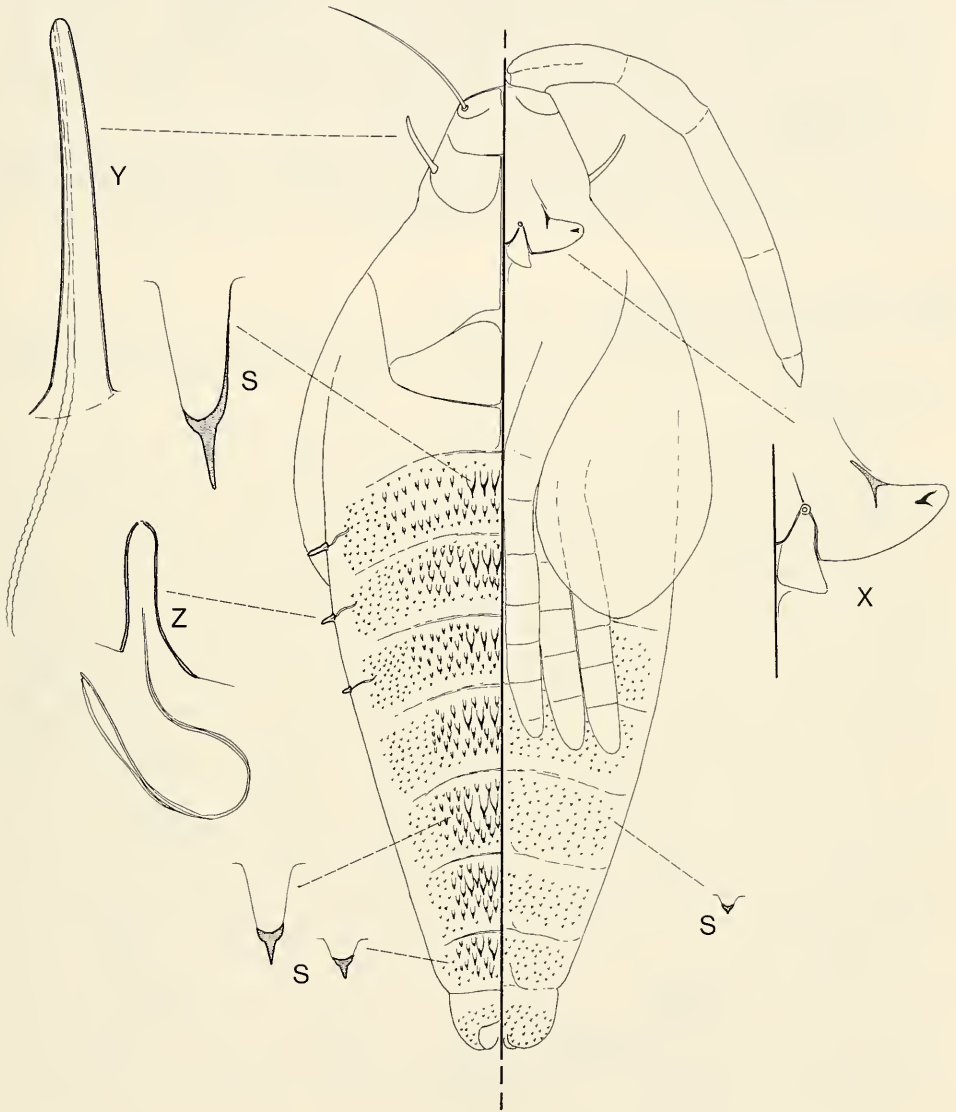


Figure 8. Pupa of an unidentified species of Cecidomyiidae (Diptera) found amongst the coccid crawlers under the abdomen of an adult female of *A. sassafras*. Letters refer to the following structures: S, abdominal dorsal spine (large medial projection) or spicule (small ventral or dorsolateral projection); X, lower part of face; Y, prothoracic spiracle with trachea ending at apex; Z, abdominal spiracle.

collection are included as paralectotypes because Froggatt based his descriptions on unmounted material and thus all of his specimens must be considered as syntypic.]

Other material examined

NEW SOUTH WALES: 7 adult females, 77 first-instar nymphs (8 slides), 3 dry-mounts with additional 3 adult females and first-instar nymphs, Nyngan, ex *Capparis*, 11.xi.1921, WWF 1061 (ANIC); 2 adult females, 56 first-instar nymphs (4 slides), 3 dry-mounts with additional 19 adult females and first-instar nymphs, same data as ANIC specimens (ASCT); 4 adult females (1 slide), Moonie River via Collarenebri, ex *Capparis mitchelli*, Oct 1911, S.W. Jackson (ASCT).

All specimens from Nyngan were collected in 1921 and, because the species was described in 1915, cannot be part of Froggatt's syntypic material. The label for the type specimens from Gunnedah does not have a date (see comment under *Biological notes*).

Description of adult female

(Fig. 4, 9) (measurements based on 10 specimens)

Live specimens (according to Froggatt 1915) dark chocolate brown with lighter-coloured edges to body when mature; of lighter coloration with yellow body margin when immature.

Body oval and usually asymmetrical, 2.9–5.8 mm long, 2.1–4.5 mm wide.

Dorsum with membranous derm except for narrow, heavily sclerotised crescents around margin of each stigmatic cleft and slight sclerotisation posterior to anal plates on older specimens. Eyespots displaced from margin, just anterior to level of antennal bases. Dorsal setae bluntly spinose, tending to clavate especially on posterior abdomen, 7–13 μm long, sparse throughout but most frequent in a broad submarginal band; scarce medially. Dorsal pores or pore-like structures of 3 kinds: (i) minute microductules, 1 μm in diameter, with inner ductule 10–13 μm long, broadly tubular proximally, filamentous distally, frequent and fairly evenly distributed throughout; (ii) simple, closed 'pores' (probably areas of thin cuticle), 2.5–5 μm in diameter, in a broad submarginal band and apparently absent medially; and (iii) preopercular pores, flat with a slightly granulate surface, irregularly oval to circular, 4–7 μm diameter, in a group on either side of anal plates and extending anteriorly in 2 sparse, broad, diverging lines to about prothorax. Anal plates each triangular, with anterior margin slightly shorter than posterior margins, each plate 153–172 μm long, 70–78 μm wide; with 2 setae apically on each plate, a slightly longer seta posteriorly on inner margin and a shorter seta posteriorly on posterior margin. Anogenital fold with 0–1 pair of setae along anterior margin, 15–25 μm long; with 1 pair setae at posterior end of lateral margins of anal cleft, 12–15 μm long. Anal tube subequal or a little longer than length of anal plates; anal ring 60–73 μm in diameter, with 3 pairs of setae, each 175–250 μm long.

Margin with bluntly spinose setae, each generally bent, with a slightly clavate apex; distinctly longer than dorsal setae, 17–33 μm long, in a single marginal row but absent from stigmatic clefts and anal cleft; with 11–24 setae laterally between stigmatic clefts; anal lobe setae not differentiated. Each stigmatic cleft with a well defined area of sclerotisation around inner margins; each cleft usually with 2 (rarely 1, 3 or 4) stigmatic spines; anterior stigmatic spine 28–44 μm long, posterior spine 38–50 μm long, both spines parallel-sided with a rounded apex.

Venter with segmentation only visible on abdomen. Ventral setae flagellate, 7–38 μm long, very sparse on head and thorax, most abundant medially on abdomen and especially mediolaterally on anal lobes where longest; pregenital segment (VII) with a single pair of long (110–140 μm) pregenital setae and paired lateral groups of 6–12 short flagellate setae plus 1–3 setae of intermediate length; other setae medially on abdomen, with pairs per segment: VI 6–12; V 6–10; IV 2–4; III 4–7; II 3; also with 1 pair of interantennal setae; submarginal setae very sparse. Pregenital disc-pores rather misshapen, usually

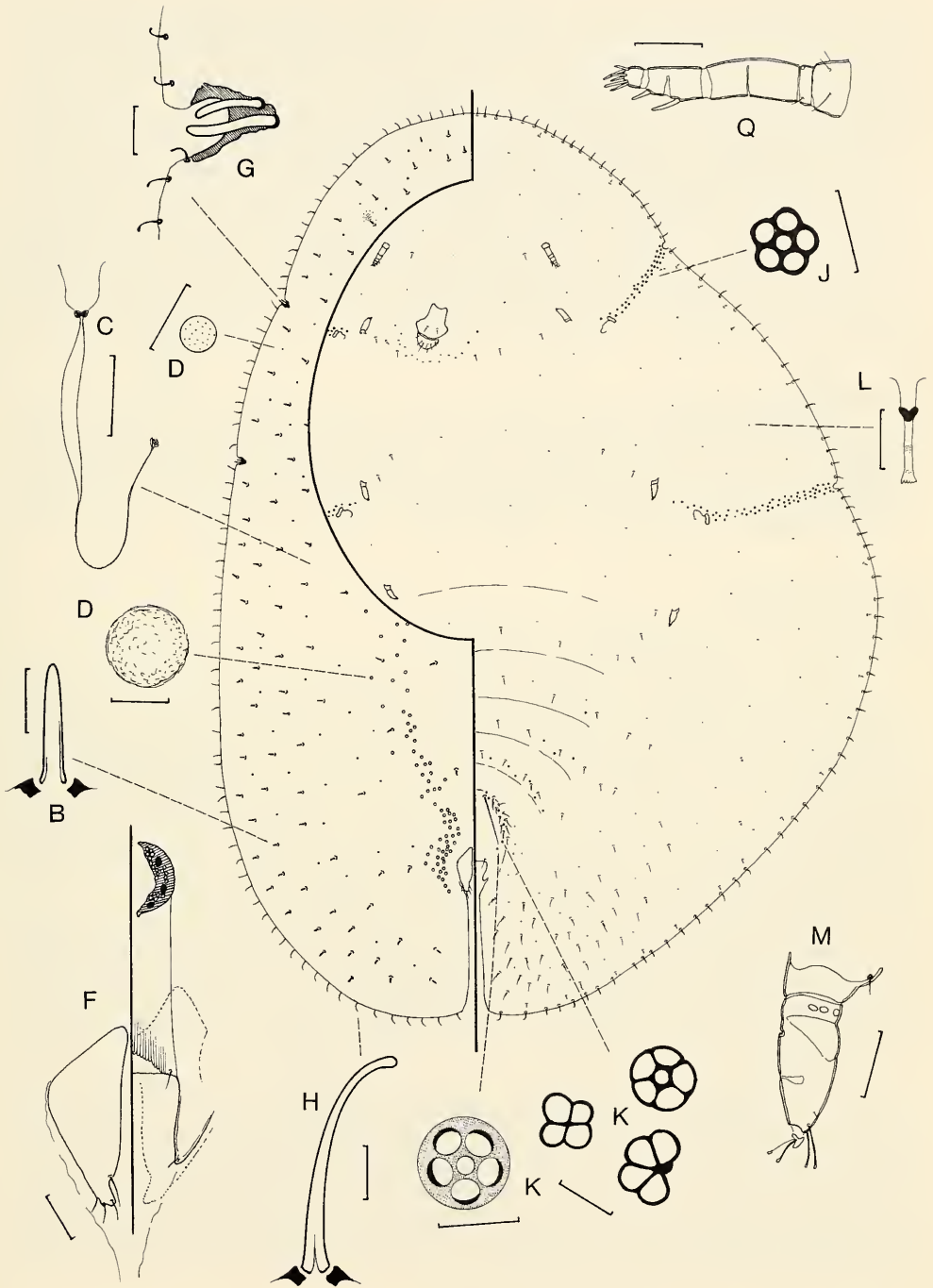


Figure 9. Adult female of *Austrolecanium cappari* (Froggatt). Lettering and scale lines as in Fig. 1, except that the scale line for the stigmatic cleft (G) = 25 μ m.

with 7–9 loculi, 3–6 μm diameter, present as follows: pairs per segment: VII 4–9; VI 4–11; V 0–4; IV 0–4; III 0–1; II 0. Each stigmatic furrow with a band of 30–62 spiracular disc-pores extending from spiracle to stigmatic cleft, each band about 1–3 pores wide, each disc-pore 3–5 μm diameter and usually with 5 loculi; each band with 1–7 disc-pores extending a short distance medially past peritreme. Ventral microducts as in generic description. Spiracles: anterior spiracle plus peritreme 45–60 μm long, 42–50 μm wide; posterior spiracle plus peritreme 50–70 μm long, 42–55 μm wide. Legs each 50–85 μm long; tarsal digitules 10–22 μm long, 1 digitule longer and broader than other, both narrow with minute apical knobs; claw digitules 7–16 μm long, parallel-sided, with only slight apical knobs. Antennae each with about 6 indistinct segments; total length 110–145 μm ; with all setae on terminal 3 segments fleshy, 7–19 μm long. Mouthparts generally positioned slightly nearer shorter margin of body. Clypeolabral shield 140–160 μm long, 145–160 μm wide. Labium 55–70 μm long, 90–110 μm wide, sometimes twisted through 90.

Diagnosis of adult female

The adult female of *A. cappari* can be separated from that of *A. sassafra*s in possessing the following features: (i) usually only 2 stigmatic spines per stigmatic cleft; (ii) marginal setae longer than dorsal setae; (iii) dorsal setae spinose and rather concentrated in a broad submarginal band; (iv) ano-genital fold with only 1 pair of small setae on lateral margins of each supporting bar, and (v) 3 pairs of setae in anal ring.

First-instar nymph

(Fig. 10) (measurements based on 10 specimens)

Body oval, 450–590 μm long, 290–330 μm wide.

Dorsum with dorsal setae about 2 μm long. Dorsal pores consisting of: (i) simple pores, 2–3 μm in diameter, present in a submarginal line extending from head to posterior abdomen and occasionally elsewhere; (ii) microductules enlarged into ‘figure-of-eight’ pores (greatest width of pore 5–6 μm), each possessing an inner ductule (15–22 μm long) with a broad proximal end (6–8 μm long) and a longer filamentous distal end, present in segmental bands of about 12 pores across each abdominal and thoracic segment and also \pm randomly on head; and (iii) a pair of small trilocular pores near anterior margin on head. Anal plates each 42–50 μm long, 20–25 μm wide; each with apical seta 160–210 μm long. Anal ring 20–25 μm in diameter, with setae 45–50 μm long.

Margin with setae, 6–18 μm long, each distinctly bent posteriorly. Stigmatic clefts clearly present in older specimens, less obvious in young specimens; each stigmatic area with a distinct stigmatic sclerotisation and 2 stigmatic spines; more anterior spine slightly more than half length of posterior spine (lengths 5–10 μm and 8–16 μm , respectively); usually with a marginal seta very close to but not within posterior margin of stigmatic sclerotisation.

Venter with pregenital setae 35–45 μm long (a few individuals also with single long setae on segments VI and V), interantennal setae 20–30 μm long, all other setae 3–8 μm long. Spiracular disc-pores each 3–5 μm in diameter and with 3, 5 or 7 loculi; 3–6 pores in anterior furrows and 4 pores in posterior furrows. Spiracles: length of each muscle plate plus peritreme 16–20 μm ; width of peritreme 7–10 μm . Legs as in generic description. Antennae 180–190 μm long; on terminal segment: apical seta 30–38 μm long, longest flagellate seta 40–53 μm long. Clypeolabral shield 90–95 μm long, 80–95 μm wide. Labium 30–38 μm long, 50–65 μm wide.

Diagnosis of first-instar nymph

The first-instar nymph of *A. cappari* differs from that of *A. sassafra*s mainly in having much enlarged dorsal microductules that resemble ‘figure-of-eight’ pores.

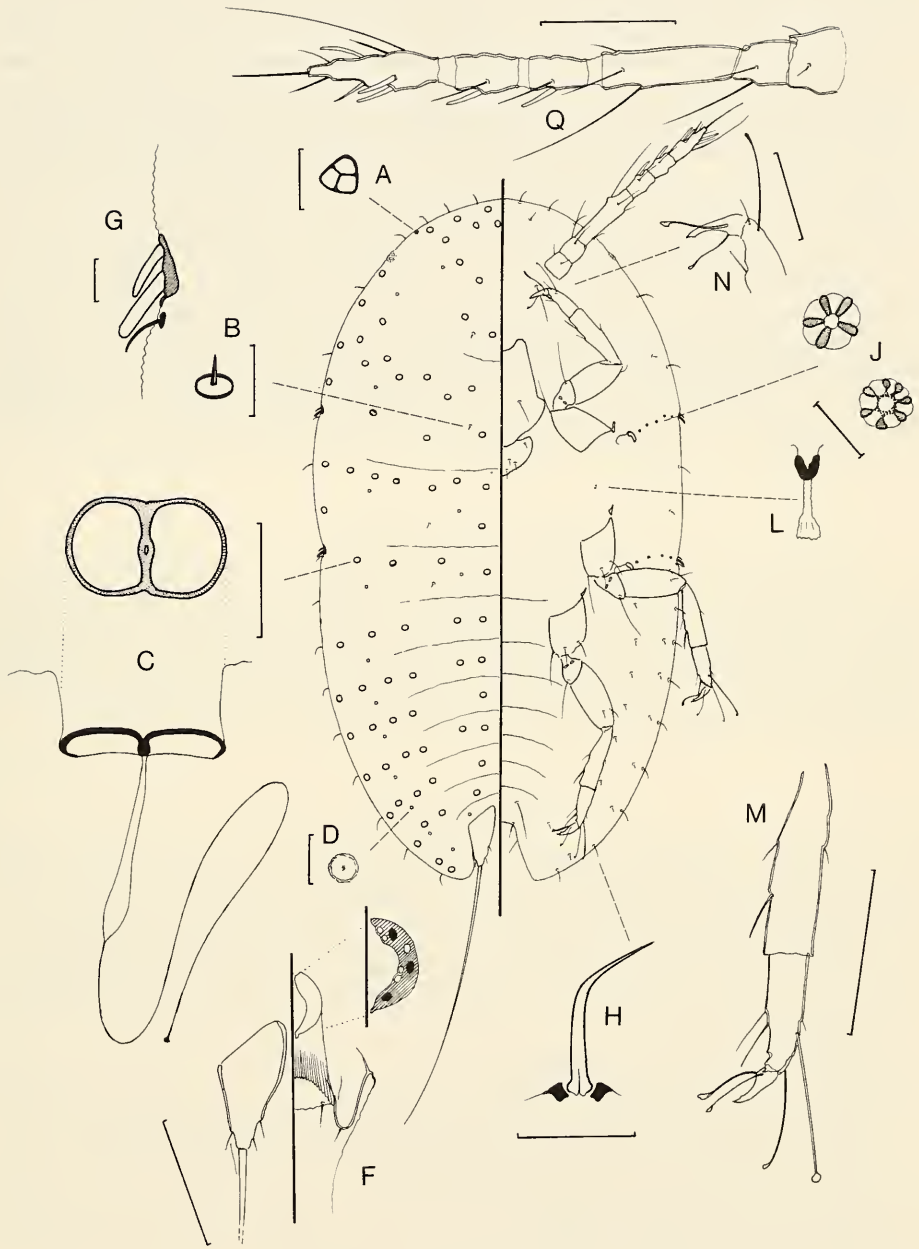


Figure 10. First-instar nymph (crawler) of *Austrolecanium cappari* (Froggatt). Lettering and scale lines as in Fig. 1, except that the scale line for the prothoracic claw (N) = 25 μ m and the stigmatic cleft (G) = 5 μ m.

Biological notes

The first-instar nymphs of *A. cappari* were obtained from small aggregations (Fig. 4) under the abdomen of several dry adult females that were attached to leaves and from inside the body cavity of the mothers. *A. cappari* is clearly ovoviviparous. Crawlers were found under most of the adult females collected in November 1921 at Nyngan. There were no crawlers under the adult females from Gunnedah; the date of collection of these latter specimens is not given on the labels, but from the sequence of entries in Froggatt's accession notebook (housed in ASCT), they appear to have been obtained in mid-1910. No other immature stages are present in Froggatt's collection, although he referred to the male tests as being '... white, semi-transparent, elongate oval, flattened, with a white line on either side, converging to a point at the posterior angle. Lateral plates finely crenulate on the margins. Length, $\frac{1}{13}$ of an inch [= c. 2 mm].' (Froggatt 1915, p. 605).

Only the host-plant genus, *Capparis*, is recorded on Froggatt's original material. However, both Froggatt's original description and his accession notebook record '*Capparis mitchelli*' [sic] as the host plant for both the Gunnedah and Nyngan collections. Furthermore, Froggatt's dry material consists of whole leaves bearing coccids and these leaves match those of *C. mitchellii*, as illustrated by Harden (1990b). *C. mitchellii*, which is known commonly as wild orange or native orange, is found in all mainland states but especially in inland northern New South Wales (Cunningham et al. 1981; Harden 1990b).

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